VII. "Note on the Photographic Spectra of Uranus and Saturn." By WILLIAM HUGGINS, D.C.L., LL.D., F.R.S., and Mrs. HUGGINS. Received June 5, 1889.

Uranus.—In 1871 I had the honour to communicate to the Royal Society an account of the examination of the visible spectrum of Uranus.* The visible spectrum of this planet is remarkable, as it is seen to be crossed by several strong lines of absorption. Six of these dark bands are shown in a diagram which accompanies the paper, and their approximate positions in the spectrum are given. The spaces between the dark bands appear bright by contrast, and might suggest at first sight bright bands. I was unable to use a slit sufficiently narrow to enable me to determine whether the bright parts of the spectrum contain the Fraunhofer lines, which would be the case if Uranus, like the other planets, shines by reflected solar light.

The spectrum of this planet was carefully examined in 1872 by Vogel,† whose results are in accordance with my earlier ones. He observed some fainter lines or bands, in addition to those given in my paper. Vogel was unable to obtain evidence of the Fraunhofer lines. His observations agree with mine in placing a dark band at the position of F in the solar spectrum.‡

In consequence of the Fraunhofer lines not having been seen, a presumption has arisen that Uranus may shine, in part at least, by emitted light.

It appeared to me that this question might be answered by photography. With an exposure of two hours, I obtained on June 3 a photograph of the spectrum of the planet from a little above F to beyond N in the ultra-violet. A pair of sky spectra, one on each side of the planet's spectrum, were taken on the same plate.

The spectrum of Uranus, though fainter, shows all the chief Fraunhofer lines seen in the comparison spectra, and is clearly solar. I have not been able to detect any indications of bright lines, nor of any strong bands or groups of absorption, such as those in its spectrum from F to C.

There can be no doubt that the spectrum of Uranus, at least, from a little above F to beyond N in the ultra-violet, is due to reflected solar light. I have not yet been able to re-examine the visible spectrum of the planet.

Saturn.—In 1864, I gave an account of an examination of the

* 'Roy. Soc. Proc.,' vol. 19, p. 488.

† 'Untersuchungen über die Spectra der Planeten,' Leipzig, 1874.

‡ Measures of some of the bands were made at Greenwich in 1882. See 'Greenwich Spectroscopic and Photographic Results,' 1882, p. 33.

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visible spectrum of this planet and its rings. In my paper on the "Photographic Spectra of Stars,"* I described the photographic spectra of Venus, Jupiter, and Mars. About a year later I took a photograph of the spectrum of Saturn and his rings, but as it did not present any new features, but was purely solar, I have not given any description of it.

The favourable position of Saturn this year for obtaining a photograph in which the spectra of the ansæ of the rings could be seen distinct from the spectrum of the ball and of the part of the ring crossing it, determined me to take some photographs of the planet and its rings.

I have adopted the plan described in 1880, in which the planet is photographed while the sky is sufficiently bright to give a faint daylight spectrum on the plate. Any additional lines or other modifications of solar light due to the planet's atmosphere can in this way be easily detected.

In the photographs taken this year the slit was so placed upon Saturn that the spectrum consists of three distinct parts, the middle part being formed by the light from the ball, and the part of the ring across it, and on both sides of this spectrum the spectra of the ansæ. The planet was kept upon the same part of the slit with sufficient exactness to keep these three spectra distinct, and from encroaching upon each other, and therefore if any difference existed between them it could be detected.

The exact correspondence of the Fraunhofer lines in the spectrum of the planet and its rings with those of the sky spectrum is clearly shown, but I am unable now, as I was in 1881, to detect any lines, dark or bright, other than those which are also present in the sky spectra. The spectrum on the plate extends from a little above F to beyond N in the ultra-violet.

I am trying to obtain enlargements of the spectra of Saturn and Uranus to serve as illustrations to this note. If they can be done so as to admit of reproduction, I will do myself the honour to present them to the Royal Society.

[We have observed since, the visible spectrum of Uranus, but under unfavourable conditions, the planet being low and the sky not dark. These observations confirm me strongly in the opinion I formed in 1871 that the brighter parts of the spectrum appear so as an effect of contrast, and do not represent emitted light. In the moments of best vision the spectrum on both sides of the brighter parts appeared to be darkened by groups of lines which give a heightened effect by contrast to the less obscured parts between them.

* 'Phil. Trans.,' 1880, p. 669.

At moments, we were conscious of dark lines crossing the spectrum, but the unfavourable conditions under which the observations were made prevented us from ascertaining by measurement or otherwise, whether any of these lines were Fraunhofer lines.—July 5.]

VIII. "The Physical Properties of Vulcanised India-rubber." By A. MALLOCK. Communicated by Lord RAYLEIGH, Sec. R.S. Received May 9, 1889.

Considering the wide use now made of india-rubber, it seems curious that the elastic constants which define its properties should not be as well known as the corresponding quantities for iron or brass.

The only published quantitative measure, however, with which I am acquainted, relating to the subject, is contained in a paragraph of Thomson and Tait's 'Natural Philosophy' (p. 230, Part II, New Edition), where the resilience of vulcanised india-rubber, *i.e.*, the amount of work restored by the substance when allowed to return to its equilibrium form, after having been stretched to a maximum short of rupture, is stated to be equivalent to its own weight raised through 1200 metres.

In 1885 I made some measures of the value of Young's modulus for india-rubber, and also examined the effect of continued strain on the material, but at that time I was not aware how much different kinds of india-rubber differed from one another in these respects, and the experiments were made on one kind of vulcanised rubber only, namely, a soft grey sort, which when cut, shows small spots of a yellowish-grey scattered throughout its substance. This year I resumed the experiments, using specimens of three different kinds of vulcanised india-rubber made at Silvertown. The specimens were cut from a sheet half an inch thick, and were square in section, and one foot long.

One was a soft grey kind, apparently identical in properties with that experimented on in 1885. The next was the well-known red sort, and the third a dark grey, much harder and stiffer than the two former.

On these specimens experiments were made to determine the three elastic constants, viz., Young's modulus, the simple rigidity, and volume elasticity. The apparent viscosity was also measured, and the behaviour of the materials under great strains, and strains continued for long periods, observed.

Young's modulus and the simple rigidity were each measured in two ways, statically and dynamically. The statical measurements being made by observing the extension and angle of torsion produced by a known force and moment; while for the dynamical measures the